MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 3, 2015/2016

EME3206 – CONTROL ENGINEERING

(ME)

01 JUNE 2016
9.00 AM - 11.00 AM
(2 Hours)

INSTRUCTIONS TO STUDENTS

1. This Question paper consists of 6 pages including cover page with 4 Questions only.
2. Attempt **ALL** questions. All questions carry equal marks and the distribution of the marks for each question is given.
3. Please write all your answers in the Answer Booklet provided.
4. Table of Transform pairs has been included in Appendix.

Question 1

(a) A control engineer, N.Minorsky, designed an innovative ship steering system in 1930's for the U.S. Navy. The system is represented by the block diagram shown in Fig. Q1(a), where C(s) is the ship's course and R(s) is the desired course.

(i) Determine the transfer function $\frac{C(s)}{R(s)}$, using block diagram reduction technique.

(ii) Draw the sginal flow graph.

[14 + 5 marks]

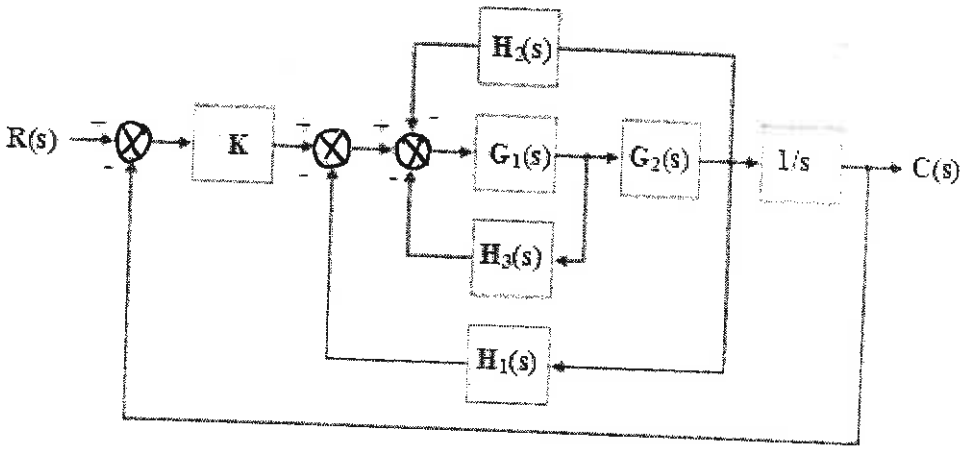

Fig. Q1(a)

(b) A robot includes significant flexibility in the arm members with a heavy load in the gripper. A two mass model of the robot is shown in Fig. Q1(b). Write the equations of motion in s-domain. You need not solve these equations.

[6 marks]

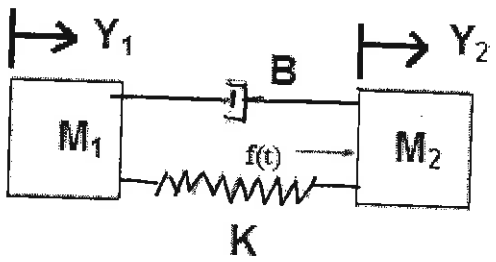

Fig. Q1(b)

Continued...

Question 2

(a) A spring mass damper system has the following transfer function:

$$G(s) = \frac{49}{s^2 + 5s + 49}$$

(i) Find the damping ratio (ξ).
(ii) State whether the system response is under-damped, critically-damped or over-damped.
(iii) Find the rise time.

[3+2+2 marks]

(b) The open-loop transfer function of a unity feedback system is given.

$$G(s) = \frac{5}{s(s+6)}$$

Determine the time response *c(t)* when input is unit-step. [8 marks]

(c) The open loop transfer function of a unity feedback system is given.

$$G(s) = \frac{25}{s(s+5)}$$

Determine the steady state error for step, ramp and parabolic inputs. [2 +2 +2 marks]

(d) Define phase margin and gain margin in a Bode plot [2+2 marks]

Continued...

Question 3

(a) The open loop transfer function of a unity feedback system is

$$G(s) = \frac{1}{2s^4 + 5s^3 + s^2 + 2s}$$

Using Routh – Hurwitz criteria,

(i) Determine the stability of the system.
(ii) Find how many roots are lying on the left hand side and right hand side of the s-plane.

[10+ 2 marks]

(b) Consider a closed loop control system as shown in Fig. Q3 (b).

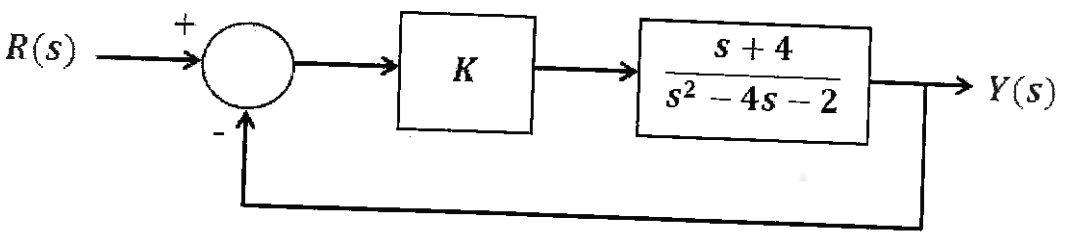

Fig. Q3 (b)

Find the following:

(i) Start and end points of all branches.

(ii) Number of branches. [3 marks]

(iii) Asymptote. [1 marks]

(iv) On locus points of the imaginary axis, and the corresponding K value. [3 marks]

[6 marks]

Continued...

Question 4

The differential equation of a mechanical system is given as

$$\frac{d^3y(t)}{dt^3} + 5\frac{d^2y(t)}{dt^2} + 8\frac{dy(t)}{dt} + 5y(t) - u = 0.$$

(i) Obtain the state equations and output equations of the system

[11 marks]

(ii) Obtain the state space model of the system

[5 marks]

(iii) Draw the state diagram of the system

[5 marks]

(iv) Find the characteristics equation of the system.

[4 marks]

Continued...

Appendix – Laplace Transform Pairs

f(t)	F(s)
Unit impulse δ (t)	1
Unit step u(t)	$\frac{1}{s}$
t	$\frac{1}{s^2}$
$\frac{t^{n-1}}{(n-1)!}$ (n = 1, 2, 3, …)	$\frac{1}{s^n}$
t^n (n = 1, 2, 3, …)	$\frac{n!}{s^{n+1}}$
e^{-at}	$\frac{1}{s+a}$
te^{-at}	$\frac{1}{(s+a)^2}$
$\sin \omega t$	$\frac{\omega}{s^2+\omega^2}$
$\cos \omega t$	$\frac{s}{s^2+\omega^2}$
$e^{-at} \sin \omega t$	$\frac{\omega}{(s+a)^2+\omega^2}$
$e^{-at} \cos \omega t$	$\frac{s+a}{(s+a)^2+\omega^2}$
$1-\cos \omega t$	$\frac{\omega^2}{s(s^2+\omega^2)}$
$\omega t - \sin \omega t$	$\frac{\omega^3}{s^2(s^2+\omega^2)}$
$\sin \omega t - \omega t \cos \omega t$	$\frac{2\omega^3}{(s^2+\omega^2)^2}$
$\frac{1}{2\omega} t \sin \omega t$	$\frac{s}{(s^2+\omega^2)^2}$
$t \cos \omega t$	$\frac{s^2-\omega^2}{(s^2+\omega^2)^2}$

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